

On the classification of water temperature during whole-body immersion in healthy individuals based on human thermoregulation and thermal perception: A scoping review

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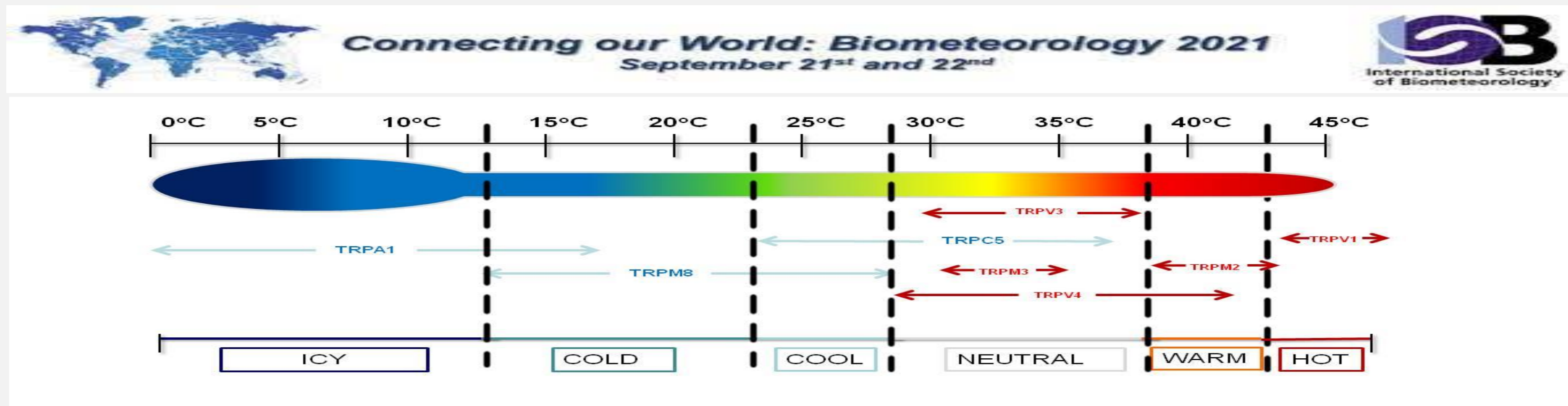
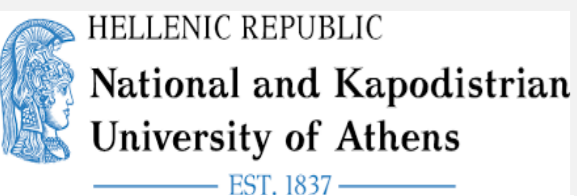


Fig. 1 depicts TRP ion channels activation matched with our 6-point thermal scale. Each selected temperature ranges has been chosen depending on how a subject expressed his own thermal sensation after a 10 min water immersion and with what is known about the activation of TRP ion channels.

INTRODUCTION

- Severe discomfort or even drowning incident may lurk during prolonged exposure to noxious water temperatures
- Therefore, particular emphasis should be given to thermal perception, as it can predict the thermal load of the human body
- There is no thermal sensation model for water immersion as a "gold standard"

OBJECTIVE

- To highlight the empirical thermal assessment from olden times
- To propose a simple thermal perception index for plain water immersion

METHODOLOGY

- The methodological basis was the approach of scoping literature review as referred by Munn et al. (2018).
- We tried to connect clinical trials related to thermoregulatory responses during whole-body water immersion in healthy individuals after 10 min immersion with the basic theory about how the transient receptor potential (TRP) temperature sensors affect thermal homeostasis and perception.

Marotta (1933)	Kappelmeyer-Haenel (1974)
Hyperthermal > 38°C	Hyperthermal >38°C
Mesothermal 30-40°C	Mesothermal 34-38°C
Hypothermal 20-30°C	Hypothermal 20-34°C
Thurner (1967)	Castany (1963)
Hot >32°C	Hyperthermal 50-100°C
Warm 25-32°C	Mesothermal 35-50°C
Slightly warm 20-25°C	Hypothermal 20-35°C

Table 1. Medical Hydrologists' classification system

RESULTS

- Determination of thermal descriptors for water is purely vague based primarily on perceptual assessments, which are not universal. Thus, there are many classifications systems (Table 1, 2).
- Both hydrologists and health scientists characterized cold the water <20°C implying a strong association between mind – body – TRPs.

Ledo (1996)
Very cold (0-12°C)
Cold (12-18°C)
Fresh (18-27°C)
Neutral (27-32°C)
Warm (32-36.5°C)
Hot (37-40°C)
Very hot (40-43°C)

Table 2. Spa – classification system

We developed a conceptual six-point thermal scale with the following specific water temperature ranges: icy <12°C, cold 12-24°C, cool 24- 29°C, neutral 29-38°C, warm 38-43°C, and hot >43°C (Fig. 1)

- The common reaction between icy and hot zone is the activation of nociceptive thermoreceptors, such as TRPA1 and TRPV1, causing unbearable pain that steers to the inability to complete a prolonged water immersion.
- Both cold and warm zone alters the core temperature and others cardiovascular factors, mainly due to TRPM8's action for cold and TRPV4, TRPM2's action for warm stimuli.
- None other than shivering thermogenesis is observed in the cool zone.
- In terms of TRPs, the complex neutral zone is a dynamic intermediate state not presenting shivering thermogenesis, sweating activity, and changes in core temperature.

CONCLUSION

The classification of water temperature according to our thermal sensation model will assist in charting the human physiological responses and enlighten the significance of thermal sensation as an indicator for aquatic safety.